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INTRODUCTION.

This REVIEW treats generally the meteorological conditions of the United States and Canada for March, 1889, and is based upon reports of regular and voluntary observers of both countries.

On chart i the paths of the centres of nine areas of low pressure are shown; the average number traced for March during the last fifteen years being 11.7. This chart also exhibits the approximate paths of the centres of twelve depressions traced over the north Atlantic Ocean; the limits of fog-belts west of the fortieth meridian, and the distribution of field ice during the month. Unusually severe weather prevailed over the western part of the north Atlantic, and there was a remarkable deficiency of Arctic ice, this being the first March in the last eight years for which large quantities of icebergs and field ice were not reported over and near the Banks of Newfoundland. The areas of high and low pressure and north Atlantic storms are discussed under their respective headings.

Chart ii exhibits the distribution of mean atmospheric pressure and temperature for the month. The mean temperature was generally above the normal, except in districts lying south of the thirty-fifth parallel and east of the one hundred and twelfth meridian. The greatest departures above the normal occurred in the north-central part of the country, where, at stations, they exceeded 15°. The departures below the normal were less than 5°, except in the lower Rio Grande valley. At a number of stations distributed from the Atlantic to the Pacific oceans the highest absolute temperature noted during the periods of observation was reported.

The distribution of precipitation for March, 1889, is shown on chart iii, and the normal precipitation for eighteen years is exhibited on chart iv. A notable feature of the precipitation of the month was the heavy rainfall on the middle and southern Pacific coast, where more than double the usual amount of rainfall for March fell. In Florida the precipitation exceeded the normal by nearly one hundred per cent. The greatest deficiency occurred in the upper lake region, where forty per cent. of the normal fell, and in the Ohio Valley, Tennessee, the extreme Northwest, and upper Mississippi valley, where about one-half the usual amount was reported.

Chart v exhibits the depth of snow on the ground at the close of the month, and the limits of freezing weather during March, 1889.

Commencing with July, 1888, the meteorological means for the regular stations of the Signal Service have been determined from observations taken twice daily at 8 a. m. and 8 p. m. (75th meridian time). These hours of observation have been permanently adopted to supersede the former system of tri-daily observations taken at eight-hour intervals. The monthly mean temperature for Signal Service stations represents the mean of the maximum and minimum temperatures.

In the preparation of this REVIEW data from 1,969 stations have been used, classified as follows: 175 Signal Service stations; 108 monthly registers from United States Army post surgeons; 1,182 monthly registers from state weather service and voluntary observers; 23 Canadian stations; 165 stations, through the Central Pacific Railway Company; 316 marine reports through the co-operation of the Hydrographic Office, United States Navy; marine reports through the "New York Herald Weather Service;" monthly weather reports from the local weather services of Alabama, Arkansas, Colorado, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Michigan, Minnesota, Mississippi, Missouri, Nebraska, Nevada, New England, New Jersey, New York, North Carolina, Ohio, Oregon, Pennsylvania, South Carolina, Tennessee, and Texas; international simultaneous observations; trustworthy newspaper extracts, and special reports.

ATMOSPHERIC PRESSURE (expressed in inches and hundredths).

The distribution of mean atmospheric pressure for March, 1889, as determined from observations taken daily at 8 a. m. and 8 p. m. (75th meridian time), is shown on chart ii by isobars. On July 1, 1888, the tri-daily observations of the Signal Service were superseded by observations taken twice daily at the hours named. A protracted series of hourly observations has shown that the difference is almost inappreciable between the mean pressure obtained from two observations taken at these hours and that determined from tri-daily observations taken at eight-hour intervals.

For March, 1889, the mean pressure was highest within an area bounded by the isobar of 30.10, which extended from Manitoba southward to Kansas, the highest reading, 30.12, being noted at Bismarck, Dak. From this region there was a decrease in mean pressure westward to the north Pacific coast, where the readings fell below 29.90; southward to the southeastern slope of the Rocky Mountains, where the means were below 30.00; and eastward to Nova Scotia, where values falling below 29.85 were shown, the lowest mean reading reported, 29.82, being noted at Yarmouth, N. S. Within a well-defined area of relatively low mean pressure which occupied southeastern California and southwestern Arizona, and along the Pacific coast north of the fortieth parallel, the values fell below 29.95.

A comparison of the March, 1889, pressure chart with that of the preceding month shows a general decrease in pressure over the United States and Canada, the decrease being most marked from Oregon southeastward over the middle plateau region, on the middle Gulf coast, and along the middle Atlantic and North Carolina coasts, where at stations the mean readings were .25, or more, below those of February, 1889. Over the extreme southwestern part of California the decrease amounted to but .05; over the north-central portion of the country, and at the mouth of the Rio Grande River, to .10 or less, and over southern Florida to .12. The area of highest mean pressure

occupied the middle and northern plateau regions of the Rocky Mountains in February, while for March the highest readings were reported in the Missouri and Red River of the North valleys. The lowest mean values for March, 1889, were, as in the preceding month, noted at stations in the Canadian Maritime Provinces.

Compared with the normal pressure for the month, the mean barometer readings for March, 1889, were above the normal from the upper Mississippi valley and the upper lakes westward to the plateau regions of the Rocky Mountains, the greatest departures above the normal being shown within an area extending from Montana southward to Colorado, where they exceeded .05. In all other districts, save at stations in the lower Rio Grande valley and at Port Huron, Mich., the mean pressure was below the normal, the departures being most marked along the middle and south Atlantic and east Gulf coasts, and on the Pacific coast south of the Columbia River, where they were more than .10. At stations in the Canadian Maritime Provinces, and from the Lake region southwestward to Texas, the departures below the normal averaged from .01 to .02.

BAROMETRIC RANGES.

The monthly barometric ranges at the several Signal Service stations are given in the table of miscellaneous meteorological data. The general rule, to which the monthly barometric ranges over the United States are found to conform, is that they increase with the latitude and decrease slightly, though somewhat irregularly, with increasing longitude. In March, 1889, the ranges were greatest in New England, where they amounted to 1.70, whence they decreased to the upper Mississippi valley and the upper lake region, where they were less than .70. From this region they increased westward to the north Pacific coast, where they amounted to 1.30, and southward to the Indian Territory, where they exceeded 1.10. Along the Atlantic coast the extreme ranges varied from .54 at Key West, Fla., to 1.70 at Portland, Me.; between the eighty-second and ninety-second meridians, .76 at Cedar Keys, Fla., to .90 at Vicksburg, Miss., and Memphis, Tenn.; between the Mississippi River and Rocky Mountains, .55 at Brownsville, Tex., to 1.11 at Fort Sill, Ind. T.; in the plateau and Rocky Mountain regions, .43 at Fort Grant, Ariz., to 1.09 at Walla Walla, Wash.; on the Pacific coast, .51 at San Diego, Cal., to 1.30 at Fort Canby and Tatoosh Island, Wash.

AREAS OF HIGH PRESSURE.

Nine areas of high pressure were observed within or near the limits of stations of observation during the month of March. Four of these areas were traced directly from the Pacific to the Rocky Mountain regions. The direction of movement, while the centre of greatest pressure remained west of the Rocky Mountains, was generally to the northeast, and after crossing the Rocky Mountains the direction changed to southeast. Four were first observed in the northern Rocky Mountain region, and with one exception they passed southeasterly over the Rocky Mountain slope to the Mississippi Valley. Of the nine areas observed only four developed sufficient energy to reach the Atlantic coast, while five disappeared by gradual decreasing pressure within the limits of the stations of observation. The region over which the high areas were most numerous during the month extends from Kansas northward to Manitoba, while four areas of high pressure disappeared while over the central Rocky mountain region.

I.—The month opened with this area covering the central Rocky Mountain region, with a secondary high area extending from Florida northward to the Saint Lawrence Valley, while a depression of considerable energy covered the west Gulf. There was a general drift of these conditions to eastward during the 1st and 2d, the area of highest pressure moving to the lower Missouri valley, while the storm of the Gulf followed the general direction of the coast line, and the high area to the eastward disappeared during the 2d. This area was last marked as central near Leavenworth on the evening of the 2d, the succeeding reports indicating that it afterwards formed a part of high area number ii, which was at that time moving eastward from the north Pacific coast.

II.—When the preceding area covered the central Rocky Mountain regions the pressure increased at stations on the north Pacific coast, indicating the advance of a second high area from the Pacific during the 2d. By the morning of the 3d the centre of greatest pressure was transferred from the Pacific coast to Montana, after which the direction of movement changed to the southward, and by the morning of the 5th the centre was transferred to southern Kansas. The area decreased in energy and separated, one portion passing towards the Gulf coast, while the other remained central over the Rocky Mountain regions and disappeared by a gradual decrease of pressure, without any marked change in weather conditions.

III.—This high area apparently formed over Dakota and Montana during the 7th, bounded by the isobar of 30.20. It moved northeasterly towards Manitoba, the pressure increasing at the centre, where it remained until the morning of the 9th, after which it moved directly south to Texas, the area covering the Rocky Mountain regions and central valleys. After reaching the latitude of central Texas the course of movement changed to the eastward, and it reached the south Atlantic coast on the morning of the 12th, after which it could not be traced as a well-marked area of high pressure. The barometer attained its maximum within this area of high pressure when it was central in northern Minnesota on the 9th, the pressure being unusually low in the lower Saint Lawrence valley, and an area of low pressure extending over the north Pacific coast. The fall of temperature attending the movement of this area over the central valleys ranged generally from 10° to 20°, except in the interior of Texas, where, during the 9th, the change amounted to 32° in twenty-four hours, attended by a dry and moderate "norther" in the interior of Texas, although heavy rains occurred in southern Texas on the night of the 10th and continued on the Texas coast until the 12th.

IV.—This area probably originated to the west of the Rocky Mountains north of British Columbia, but it was first observed on the morning of the 12th central in latitude 54° N. and longitude 117° W. It was at no time wholly within the limits of stations of observation, but passed eastward to the Atlantic with an almost uniform velocity of thirty-three miles per hour, reaching the Saint Lawrence Valley on the 14th and disappearing to the east of the Maritime Provinces on the 16th. The pressure increased near the centre of this area as it approached the centre of the continent from the west, and declined while passing to the eastward over the Lake region, but there was a second increase in pressure as the centre of the area approached the Saint Lawrence Valley, the maximum being observed at Rockliffe, Ont., on the morning of the 14th.

V and VI.—High area number v remained stationary over the Lake region from the 18th to 20th, after which it apparently formed a part of number vi, which appeared over the Pacific west of California and moved northward to Oregon between the 19th and 21st, and thence eastward to the upper Missouri valley, where the course changed to the southward on the 22d, and it disappeared while central over Kansas by a gradual decrease of pressure on the 23d.

VII.—This area also appeared on the Pacific coast to the westward of California. It was observed on the 23d and moved northeasterly along the coast until the afternoon of the 24th when it was central near Olympia, Wash. From this point it moved easterly, crossing the Rocky Mountains on the 25th and remaining central near the northern boundary line of Dakota on the 27th, after which it passed southerly over the eastern slope of the Rocky Mountains, covering the central valleys on the 28th and the south Atlantic and east Gulf states on the 29th. After reaching Florida it apparently moved northeasterly and joined high area number viii off the middle Atlantic coast on the 30th.

VIII.—This area of high pressure appeared on the afternoon

of the 28th in latitude 55° N. longitude 104° W. By the morning of the 29th it was central over eastern Dakota as a well-marked area of high pressure, attended by high northerly winds in the Missouri Valley and strong northerly winds in the Lake region, with snow and freezing weather as far south as the southern portion of the Lake region. The southern course continued until the afternoon of the 29th when the centre had reached eastern Iowa, after which it moved easterly over the Lake region and then southeasterly over the middle Atlantic states, where it was apparently re-enforced by the high area from the south, the barometer on the Atlantic coast from Florida to Halifax indicating a pressure of 30.30 and above on the morning of the 31st. This extended high area disappeared rapidly to the eastward in advance of the storm-centre which at that time covered the central Mississippi valley.

IX.—This area appeared on the Pacific to the west of central California on the morning of the 28th and moved northeastward, as has been described for high areas number vi and vii. After reaching the Oregon coast on the 30th the centre of greatest pressure passed to the east of the coast line and the movement changed to the southeast, causing the area to cover the plateau and central Rocky Mountain regions on the 31st, where it remained at the close of the month, the pressure having decreased at the centre from 30.32 to 30.18.

The following table exhibits, in a concise manner, some of the more prominent characteristics of the high areas:

No.	First observed.			Last observed.		Duration.	Velocity per h'r.	Highest pressure.		
	Date.	Lat. N.	Long. W.	Lat. N.	Long. W.			Date.	Station.	Reading.
		°	°	°	°	*Days.*	*Miles.*			*Inches.*
I	1	44	106	40	95	1.5	20.0	1	Cheyenne, Wyo.	30.50
II	2	47	127	38	105	3.0	28.0	4	North Platte, Nebr.	30.44
III	7	48	106	34	77	5.0	47.0	9	Minnedosa, Manitoba	30.60
IV	12	53	118	47	62	3.5	33.0	14	Rockliffe, Ont.	30.48
V	18	48	88	48	88	2.0	?	*	P. A. Landing, Ont.	30.28
VI	19	32	124	40	102	4.0	30.0	22	Denver, Colo.	30.56
VII	23	40	128	39	68	8.0	26.0	24	Portland, Oregon	30.52
VIII	28	55	104	39	68	2.5	40.0	29	Bismarck, Dak.	30.52
IX	28	36	127	40	113	2.5	25.0	30	Roseburgh, Oregon	30.32
Means						3.6	27.7			30.47

* 19th and 20th.

AREAS OF LOW PRESSURE.

Nine well-defined areas of low pressure were observed during the month of March, tracks of the centres of which are shown on chart i. Five of these areas originated in the Rocky Mountain regions, and in each case the movement was first to the southeast, until the centre reached the central valleys or the Texas coast, when the movement changed from east to northeast. From an inspection of chart i it will be seen that the areas of low pressure to the northward changed direction at points farther to the east than the areas which were traced over the southern portion of the country. Of the nine areas of low pressure observed, six reached the Atlantic, whilst two disappeared in the central valleys, and one passed northward along the north Pacific coast and finally disappeared without causing any disturbance east of the Rocky Mountains.

I.—On the last day of the preceding month there were indications that a storm was developing south of Texas, and on the first of the month the centre of this disturbance was near Galveston, attended by heavy rains in the Gulf states. The centre of disturbance apparently followed the coast line from Texas to eastern Florida, over which section it passed during the 3d. Whilst moving over the easterly portion of this track along the Gulf coast it developed but slight energy at the land stations, the maximum wind velocity being twenty-six miles at Pensacola. After reaching the south Atlantic coast the course changed to the northward, and on the 4th it was central off the middle Atlantic coast, attended by severe northeasterly gales, which continued over the New England coast until the 7th. The disturbance increased in energy as it moved northerly, the vessel reports indicating that the gales were unusually severe between latitude N. 40° and N. 43° and longitude W. 60° and W. 70°. Near latitude N. 40° and longitude W. 67° the course of this storm changed to north and passed along the New England coast from Maine to the Saint Lawrence Valley, apparently reaching its maximum energy on the 6th while off the New England coast. On the 9th it was central in the lower Saint Lawrence valley, when the course changed to the east and it passed over the Atlantic, after which it is described under the head of north Atlantic storms as number 5. This storm was remarkable on account of its duration, it having remained near the coast of the United States and controlled the weather conditions over a large area during the first ten days of the month, while it continued its course over the Atlantic with sufficient energy to render it possible to trace it during two days, making the life of the storm as determined by actual observations eleven days, while the indications are that it continued its course over the Atlantic. Descriptions of the storms attending this depression, as noted at Signal Service stations, are given under the heading "Local storms."

II.—The most extended storm which occurred on the Pacific coast during the month was central west of Oregon on the 11th. It apparently originated over the Pacific and approached the coast from the southwest, moving slowly northward after the centre reached the coast line, the barometer falling to 29.22 at the mouth of the Columbia River on the 14th, causing an unusual barometric gradient to the southeast. It was attended by strong winds and heavy rains over Washington Territory, Oregon, and California, the rains extending inland over the entire coast and plateau regions, and doubtless greatly improving the crop conditions over the Pacific coast regions, where the seasonal moisture is very much less than usual. This storm continued its course northward beyond the limits of stations of observation, and when last located it was central near the coast in latitude N. 50° on the morning of the 15th, there being no indication that it passed to the eastward of the Rocky Mountains, although low area number v, which developed in the central Rocky Mountain region, was apparently a secondary disturbance originating within the depression which attended this storm.

III.—This depression appeared north of Manitoba on the 12th, and moved easterly to the lower Saint Lawrence Valley. It apparently inclined towards the lake region as it passed eastward north of that section, and afterward followed the course of the Saint Lawrence Valley until it disappeared over Newfoundland on the 14th. It was at no time central within the limits of the United States, but it caused severe gales over the Maritime Provinces and strong westerly winds on the New England coast. The barometric gradient in the west quadrants was increased by a rapid advance of an area of high pressure which separated this storm from that traced as number ii on the Pacific coast. The westerly gales in the Saint Lawrence Valley were severe, the wind at Anticosti Island, Gulf of Saint Lawrence, reaching fifty-two miles per hour at 8 a. m. of the 14th. This storm continued its course over the Atlantic with increasing energy, and was afterwards traced as number 8 in the descriptions of north Atlantic storms.

IV.—This storm was at no time central within the limits of stations of observation, but its course along the Gulf stream from latitude N. 30° and N. 35° can be readily traced from observations taken at the Signal Service coast stations. It was probably central east of northern Florida on the 14th, although there are indications that it originated farther to the south. Heavy rains occurred on the south Atlantic coast on that date, attended by northerly gales, which extended to the southern New England coast on the 15th, upon which date the centre of disturbance was in about latitude N. 32°, south of Hatteras. The marine reports received indicated that it continued its northeasterly course during the 16th, after which it moved northerly towards Nova Scotia, and thence eastward over the

Atlantic, where it has been traced as number 7 of North Atlantic storms. Descriptions of the storms and high tides attending this depression, as noted at Signal Service stations, are given under the heading "Local storms."

V.—This storm has been previously referred to as a secondary disturbance attending the severe storm traced as number ii on the Pacific coast. It developed in the central Rocky Mountain regions, and was first located on the morning of the 14th as central in eastern Colorado. In this connection it may be well to note that the morning weather map of the 14th exhibited four separate storms—one on the north Pacific coast, one in the central Rocky Mountain region, one off the Florida coast, and the fourth over the Maritime Provinces. Number v moved southeasterly during the 14th, the centre passing over Indian Territory, after which it moved to the Mississippi Valley as an extended barometric trough covering the central valleys, the centre apparently moving to the northeastward attended by a loss of energy and increasing pressure at the centre of the disturbance. It disappeared during the 16th while central in the upper Mississippi Valley, without causing any marked change in the weather conditions to the eastward. It should also be noted that the minimum barometric pressure within each of the four areas central within the limits of the weather map on the 14th was recorded on that date.

VI.—Number vi developed in the central Rocky Mountain region on the 16th in the southeastern portion of a barometric trough which passed eastward from the Pacific, the principal disturbance apparently passing north to British Columbia, while this storm moved southeasterly, developing considerable energy as it passed from Colorado to the lower Mississippi valley. The winds attending this storm were unusually strong on the eastern slope of the Rocky Mountains south of the Missouri Valley, and heavy rains with severe local storms occurred on the 17th from Kansas and Missouri southward to Texas. After reaching latitude N. 35° the storm moved eastward over the Gulf and south Atlantic states, attended by general rains south of the Lake region, the centre probably reaching the Gulf Stream on the 19th, where it moved northeasterly and continued its course as number 9 of the storms of the north Atlantic.

VII.—The weather map of 8 a. m. of the 20th exhibited a barometric depression extending from the Rio Grande Valley northward to British America, with indications that a storm-centre was approaching from the region north of Dakota. The 8 p. m. weather chart of the same date exhibited a well-defined depression central in western Texas, which was apparently being forced southeasterly by an area of high pressure then central on the north Pacific coast. This storm continued its course southeasterly to the Gulf coast where it changed its course to northeast during the 22d, attended by heavy rains in the lower Mississippi valley and strong northerly winds on the Texas coast after the centre had passed over Louisiana. Strong southeasterly gales were also reported on the east Gulf coast on the morning of the 24th. After passing inland the winds diminished in force and it moved off the North Carolina coast as a disturbance of slight energy, although the reports from the Atlantic and from Sydney, C. B. I., of the 26th indicate that it was attended by severe gales after it left the coast.

VIII.—This was a slight disturbance which was central north of the Lake region on the 26th, although the preceding weather map exhibits a slight disturbance west of Lake Superior. It moved southeasterly to Lake Huron, the pressure decreasing at the centre during the movement, attended by brisk to high westerly winds over the Lake region on the 27th. From Lake Huron it passed easterly, inclining to the lower Saint Lawrence valley, this movement being followed by showers over the eastern portion of the country as far south as Tennessee and North Carolina. It extended in area as it approached the Atlantic, and was followed by a secondary disturbance which developed in the upper Saint Lawrence valley on the 29th.

IX and IX *a*.—The a. m. weather map of the 29th showed the presence of two areas of high pressure, the one covering the upper Mississippi and Missouri valleys, and the other the Pacific coast, while between these and over the Rocky Mountain regions the pressure was below 29.9, and in the regions north of Montana a well-marked area of low pressure had formed, the barometer reading 29.54 at Medicine Hat, N. W. T. and general rains were reported from the Rocky Mountains west to the north Pacific coast. This barometric trough moved slowly to the east, the storm-centre north of Minnesota inclining to the southeast, following the general course of the Missouri River, while a second disturbance (ix*a*) in the southern portion of this trough moved eastward over New Mexico and Texas, inclining to the northeast, the two disturbances uniting at the mouth of the Missouri on the morning of the 31st, forming an extended depression of an oval form, covering the country from the lower lake region southwest to Texas. At the close of the month this storm had reached the Atlantic coast, but the centre of disturbance was in the upper Ohio valley. During the passage of this low area over Texas strong gales occurred on the Texas coast, and the southerly winds reached a velocity of forty-eight miles per hour at Fort Sill, Ind. T., and Fort Elliott, Tex.

The following table exhibits the principal facts regarding these low areas:

No.	First observed.			Last observed.		Duration.	Velocity per hr.	Lowest pressure.		
	Date.	Lat. N.	Long. W.	Lat. N.	Long. W.			Date.	Station.	Reading.
		°	°	°	°	*Days.*	*Miles.*			*Inches.*
I	1	27	97	49	60	8.5	16.0	7	Portland, Maine	28.79
II	11	43	126	50	125	3.5	6.5	14	Tatoosh Island, Wash.	29.18
III	12	53	98	50	59	2.0	42.0	14	Anticosti I'd, G. of St. L.	29.40
IV	14	30	79	38	65	3.0	15.0	14	Charleston, S. C	29.52
								15	Hatteras, N. C	29.52
V	14	39	103	43	90	2.0	25.0	14	Fort Elliott, Tex	29.28
VI	16	40	105	33	76	3.0	26.0	17	Fort Sill, Ind. Ter	29.32
VII	20	34	105	36	77	5.0	20.0	25	Hatteras, N. C	29.56
VIII	26	50	88	51	65	2.0	30.0	28	Anticosti I'd, G. of St. L.	29.53
IX	29	50	110	40	83	2.0	34.0	29	Medicine Hat, N. W. T.	29.54
IX *a*	30	36	108	39	91	1.0	43.0	30	Fort Elliott, Tex	29.70
Mean.						3.2	25.8			29.38

NORTH ATLANTIC STORMS FOR MARCH, 1889 (pressure in inches and millimetres; wind-force by Beaufort scale).

The paths of the depressions that appeared over the north Atlantic Ocean during March, 1889, are shown on chart i. These paths have been determined from international simultaneous observations by captains of ocean steamships and sailing vessels, received through the co-operation of the Hydrographic Office, Navy Department, and the "New York Herald Weather Service."

Twelve depressions have been traced, the average number traced over the north Atlantic Ocean for March during the last six years being ten. Of the depressions traced for March, 1889, five were continuations of areas of low pressure which first appeared over the American continent; two were first noted south of the thirtieth parallel, from whence they moved northward; two appeared southeast, and one east, of Newfoundland, and two apparently developed east of the twenty-fifth meridian. The storms generally pursued normal east to northeast paths and were well distributed over the ocean.

Over and near the British Isles the weather continued generally stormy during the first decade of the month, and from the 18th to 20th, inclusive, the severest gales occurring on the 19th and 20th, when the barometric pressure fell to, or below, 29.00 (737). Over mid-ocean unsettled weather was almost